CORRELATION OF YIELD AND SPECIFIC GRAVITY IN A TETRAPLOID POTATO TUBERLING POPULATION

K. G. Haynes[1] and D. R. Wilson[2]

Abstract

In the fall of 1987 and 1988 true seed from 128 and 83 potato crosses, respectively, were sown in flats in the greenhouses at Beltsville, MD, and approximately 350 seedlings from each cross were transplanted into 7.6 cm pots. The largest tuber from each pot was saved for the field experiment. Tubers from the same family were bulked and shipped to Presque Isle, ME, for spring planting in 50-hill plots. Individual hills of one 50-hill plot from each of 24 randomly selected families were harvested. Within each 50-hill plot, five hills were selected based on horticultural characteristics, such as shape, size, smoothness, and freedom from defects to form the population selected for horticultural characteristics (HC). Specific gravity and yield were recorded for all hills harvested. From the remaining 45 hills, the five highest specific gravity hills were selected to form the population selected for specific gravity (SG). Those hills not selected for either horticultural characteristics or specific gravity formed the unselected population (UP). The average specific gravity for the HC was significantly ($P<0.05$) greater than the UP. There was a significant ($P<0.05$) negative correlation between yield and specific gravity in the HC and SG. There was no correlation between yield and specific gravity in UP. Selection among this plant material on the basis of horticultural characteristics resulted in a population of significantly ($P<0.05$) higher yielding plants whose average specific gravity was significantly ($P<0.05$) greater than the UP.

Compendio

En otoño de 1987 y 1988 se sembraron en bandejas, en los invernaderos en Beltsville, MD, semillas sexuales de 128 y 83 cruzamiento de papa, respectivamente.

Aproximadamente 350 plántulas de cada cruzamiento fueron trasplantadas a macetas de 7,6 cm. Se conservó el tubérculo más grande de cada maceta para experimento de campo. Tubérculos de la misma familia fue-

[1]Research Plant Geneticist, U.S. Department of Agriculture, Agricultural Research Service, Vegetable Laboratory, Beltsville, Maryland 20705.
[2]Horticulturist, U.S. Department of Agriculture, Agricultural Research Service, Vegetable Laboratory, Presque Isle, Maine 04769.
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ron reunidos y enviados a Presque Isle, ME, para ser sembrados en primavera en parcelas de 50 plantas. De una parcela de 50 plantas, se cosecharon plantas individuales de cada 24 familias seleccionadas al azar. Dentro de cada parcela de 50 plantas, se seleccionaron cinco basándose en características hortícolas tales como forma, tamaño, tersura y ausencia de defectos, para constituir la población seleccionada por características hortícolas (HC). Se registraron la gravedad específica y el rendimiento para todas las plantas cosechadas. De las 45 plantas restantes, se seleccionaron cinco con la mayor gravedad específica para formar la población seleccionada para gravedad específica (SG). Las plantas no seleccionadas ya sea por características hortícolas o gravedad específica formaron la población no seleccionada (UP). La gravedad específica promedio para la HC fue significativamente ($P<0,05$) mayor que para la UP. Existió una correlación negativa significativa ($P<0,05$) entre el rendimiento y la gravedad específica en la HC y en la SG. No existió correlación entre rendimiento y gravedad específica en la UP. La selección entre este material vegetal en base a las características hortícolas resultó en una población de plantas significativamente ($P<0,05$) de mayor rendimiento, cuya gravedad específica promedio fue significativamente ($P<0,05$) mayor que la de UP.

Introduction

All potato breeding programs begin by making numerous hybridizations between parents to obtain true seed and to subsequently produce the seedling generation, usually in a greenhouse. This seedling generation is then taken to the field to produce the first clonal generation or the tuberling generation (2). Several studies have shown that selection within the seedling generation is ineffective (6, 15), with the exception that higher yielding seedlings tend to produce higher yielding progeny (3, 4, 5, 6, 12). Several researchers have suggested that selection within the tuberling generation is as ineffective as selection within the seedling generation (1, 7, 8, 10, 14, 15). Maris (12) scored tubers for such horticultural traits as maturity, general impression, tuber yield, number of tubers per plant, mean tuber weight, date of emergence, haulm type, under-water weight, number of stems per plant, and plant height. In general, there was little correlation between the tuberling and later generations for most of these traits with the exception of maturity and tuber yield.

Little research has been done on the effect of visual selection for horticultural characteristics in the tuberling generation on specific gravity. Maris (11) found a significant positive correlation between tuber yields and under-water weight in 756 unselected fourth-year potato clones from twelve crosses. In 11 of the 12 crosses the partial correlation coefficients between tuber yields and under-water weight after elimination of the influence of maturity, were not significant. Based on these observations, Maris concluded that tuber yield and under-water weight were independent.

Using raw data collected from advanced trials of the U.S. Department of Agriculture (USDA) potato breeding program from 1972 to 1987, Haynes *et al.* (9), conducted a survey, sampling every third year, and determined that there was a significant negative correlation between yield and specific gravity for round white potatoes in three of the six years of their study. However, in five of the six years of the study there was no significant correlation of yield and specific gravity for russet potatoes.

The purpose of this study is to determine the correlation of yield and specific gravity in an unselected tetraploid tuberling population and in a tetraploid tuberling population selected for horticultural characteristics to determine the relationship between visual selection and tuberling specific gravity.

Materials and Methods

In mid-August of 1987 and 1988 true seed from 128 and 83 potato crosses, respectively, were sown in flats of Jiffy Mix in the greenhouses at Beltsville, Maryland. Approximately 350 seedlings from each cross were transplanted into Jiffy Mix in 7.6 cm clay pots during the first two weeks of September. Seedlings were harvested during a two-week period in mid-December. The largest tuber harvested from each pot was saved for the field experiment. Tubers from the same family were bulked, stored in cheesecloth bags at 4°C, and 95% relative humidity, and subsequently shipped to Presque Isle, Maine in the spring for field planting.

On 25 May to 1 June 1988 and 23-24 May 1989 tuberlings from each family were planted on the Chapman Farm, Presque Isle, Maine on a Plaisted gravelly loam soil in 50-hill plots. Tubers from each family were planted contiguously in 50-hill plots. Standard cultural practices were followed to control insects, diseases, and grasses. No irrigation was available. On 20 August and 3 September 1988 and 29 August and 5 September 1989, plants were top-killed with a split application of Diquat at the standard commercial rate, and, subsequently, the remaining vine residue removed by mechanical vine beater. On 16-26 September 1988 and 13-19 September 1989, 24 families and one 50-hill plot in each family were randomly chosen for detailed study. The 50-hill plot from each of the families in this study was divided into three populations. The five horticulturally best looking hills from each plot were identified based on general impression by considering such traits as size, shape, smoothness, and freedom from defects. These five hills formed the population selected for horticultural characteristics (HC). The tubers from each individual hill were bagged, and placed in 4°C and 95% relative humidity storage. During January in 1989 and December in 1989, specific gravity was determined by the weight in air and water method for each of the 50 hills from each family, and the five hills with the greatest specific gravity excluding those previously saved in the HC formed the population selected for specific gravity (SG). The 40 re-

maining hills formed the unselected population (UP). Average tuber yields and specific gravities were computed for each of the three populations in 1988 and 1989. The average yield and specific gravity for the populations was compared using a t-test (13).

Results and Discussion

The average yield per hill was significantly ($P<0.05$) greater for the HC than for the SG or the UP in both 1988 (Table 1) and 1989 (Table 2). In 1988, the average yield per hill was 1544, 1019, and 804 g. for the HC, the UP, and the SG, respectively. In 1989, the average yield per hill was 2009, 1465, and 1174 g. for the HC, the UP, and the SG, respectively. This general trend was observed in 21 of the 24 families in 1988 and in 17 of the 24 families in 1989.

As expected, the average specific gravity was greatest in the SG. Overall, the average specific gravity of the HC was significantly ($P<0.05$) greater than the UP in 1988 and in 1989. The average specific gravity was greatest in the SG, followed by the HC, and then the UP in 20 of the 24 families in 1988 and in 22 of the 24 families in 1989. In the two families in 1989 which did not follow this trend, the average specific gravity in the HC and the SG were equal.

The overall correlation of yield and specific gravity in the HC was -0.40 in 1988 and -0.34 in 1989. Both of these correlations were significantly less than zero, indicating that within the population selected at harvest on the basis of horticultural characteristics, there was a significant inverse relationship between yield and specific gravity. The overall correlation of yield and specific gravity in the SG was -0.34 in 1988 and -0.29 in 1989. Again, these were significantly less than zero, indicating that within the population selected solely on the basis of specific gravity there was a significant inverse relationship between yield and specific gravity. The overall correlation of yield and specific gravity within the unselected population was -0.05 in 1988 and 0.06 in 1989. Neither of these correlations was significantly different from zero, indicating that in the unselected population there was no relationship between yield and specific gravity. The overall correlation of yield and specific gravity in this experiment was -0.11 in 1988 and -0.02 in 1989. Only the 1988 correlation was significantly less than zero. The correlation of yield and specific gravity on a family basis ranged from -0.34 to 0.31 in 1988 and -0.47 to 0.53 in 1989. In 1988, three of the 24 family correlations were significantly less than zero, and one was significantly greater than zero. In 1989, one of the 24 family correlations was significantly less than zero, and two were significantly greater than zero.

Conclusions

The results from this experiment indicate that there is a strong selection pressure against specific gravity when selecting for horticultural charac-

TABLE 1.—*Average yield per hill and specific gravity for the populations selected for horticultural characteristics (HC) or specific gravity (SG) and the unselected population (UP) and the correlation of yield and specific gravity by family in 1988, and the standard error (s.e.) of the average and the number of observations (n) that went into the average.*

	Yield (g.)			Specific Gravity[1]			
Family	HC	SG	UP	HC	SG	UP	Correlation
B0835	1439	628	802	77	91	75	-0.17
B0836	1514	613	856	70	94	69	-0.22
B0838	803	293	640	89	94	76	0.03
B0845	1418	674	843	72	96	69	-0.11
B0850	1995	1308	1500	74	85	70	-0.32*
B0854	1586	879	1223	71	83	61	-0.07
B0864	837	924	617	81	86	66	0.26
B0867	1542	592	832	84	100	75	0.13
B0879	1412	996	1004	83	96	77	0.07
B0884	1229	539	809	81	102	81	-0.29*
B0892	1290	665	828	77	98	75	-0.17
B0903	2107	1316	1359	69	76	61	0.13
B0905	1441	613	704	78	93	80	-0.34*
B0909	1838	796	1161	84	103	82	0.01
B0910	1312	459	961	71	87	63	-0.26
B0913	1706	715	824	70	81	66	0.16
B0919	1783	968	1205	67	79	64	-0.07
B0927	1588	607	853	77	88	72	0.06
B0931	2067	723	1291	75	93	76	-0.16
B0933	1673	1230	1742	68	82	65	-0.22
B0941	1685	1009	849	78	91	68	0.31*
B0944	1595	939	1048	65	87	65	-0.12
B0950	1706	994	1485	79	83	73	-0.12
B0957	1481	804	943	64	76	56	0.19
Overall	1544	804	1019	75	89	70	-0.11**
s.e.	483	467	618	9	9	11	
n	120	120	919	120	120	919	

*,**Significant at the 5% and 1% level, respectively.
[1]1.0 omitted.

teristics in the tuberling generation. However, despite an overall negative correlation of yield and specific gravity in both years of the study, certain families in the population did not follow this trend. Since one of the objectives of the breeding program is to produce potential varieties of acceptable yield and specific gravity and to do so requires the production and screening of large tuberling populations initially, the correlation of yield and specific gravity needs to be examined per se, and the yield and specific gravity of individual families need to be determined in relation to the population as a whole. A significant positive correlation between yield and specific

TABLE 2.—*Average yield per hill and specific gravity for the populations selected for horticultural characteristics (HC) or specific gravity (SG) and the unselected population (UP) and the correlation of yield and specific gravity by family in 1989, and the standard error (s.e.) of the average and the number of observations (n) that went into the average.*

	Yield (g.)			Specific Gravity[1]			
Family	HC	SG	UP	HC	SG	UP	Correlation
B0968	2037	1083	1542	76	83	69	-0.20
B0971	2000	927	1103	86	101	77	0.16
B0975	1878	1111	1821	75	85	67	-0.13
B0980	1615	1581	1519	83	83	72	0.16
B0984	2166	888	1693	78	93	73	-0.27
B0986	1661	1248	1197	84	86	71	0.20
B0988	1453	1169	939	82	90	70	0.53**
B0989	1366	1132	1122	88	94	80	-0.11
B0992	1363	1193	1441	94	104	83	-0.10
B0996	2503	1512	2163	70	82	68	-0.20
B0998	1863	1153	1411	67	83	64	0.09
B1001	1978	1222	1632	72	84	65	-0.07
B1006	2232	1185	1431	79	97	75	0.03
B1011	2709	1298	1446	76	87	72	0.12
B1014	2325	783	1152	78	94	75	0.06
B1021	2097	837	1770	79	91	73	-0.47**
B1023	2123	1487	1967	82	90	77	-0.14
B1030	2058	1178	1542	70	83	64	-0.19
B1035	2350	1862	1568	76	76	62	0.27
B1036	2262	1059	1464	73	83	66	0.10
B1038	2233	875	1030	74	87	66	-0.12
B1067	2281	1349	2085	78	91	77	-0.01
B1069	1945	816	868	77	86	66	0.22
B1070	1710	1228	1041	71	88	65	0.40**
Overall	2009	1174	1465	78	88	71	-0.02
s.e.	636	614	801	9	7	10	
n	120	120	931	120	120	931	

**Significant at 1% level.
[1]1.0 omitted.

gravity would be inconsequential if the yield and specific gravity of that family were already significantly lower than the yield and specific gravity of the population as a whole. In 1988, the one family that had a significant positive correlation between yield and specific gravity (B0941) had an average yield and specific gravity for the HC that was greater than the overall average yield and specific gravity for all HC. In 1989, two families showed a significant positive correlation between yield and specific gravity. In one family (B0988), the average yield of the HC was less than the overall aver-

age yield of all HC, although the specific gravity was greater than the overall average specific gravity of all HC. In the other family (B1070) both the average yield and specific gravity of the HC were less than the average yield and specific gravity of all HC.

Initial screening of tuberling populations for specific gravity and yield is a time-consuming and costly measure. Nevertheless, some of the underlying genetic mechanisms should be studied in order to develop populations in which the negative correlation between yield and specific gravity is minimized, especially in high yielding or high specific gravity populations. However, as the results from this study show, selection among this plant material on the basis of horticultural characteristics resulted in a population of significantly higher yielding plants whose average specific gravity was significantly greater than the UP. There is a high probability that many potential high yielding and high specific gravity genotypes have already been discarded by waiting until the second or third year of visual selection before determining specific gravity. However, when additional deleterious factors are considered, such as heat sprouting, knobbiness, growth cracks, etc., it would appear that the present breeding and selection approach is effective in producing a population of high yielding genotypes of acceptable specific gravity with which to begin further evaluations. Despite the results of others (1, 7, 8, 10, 14, 15), selection within the tuberling population can be effective in the U.S.D.A. potato breeding program.

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